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Plant Recognition using Convolutional Neural Network

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***Abstract*— There are currently around 375000 known species of plants in the world. Expert botanists are able to easily classify and classify them based on either division/phylum, order, class, species, genus or family. But common people like students and new people in the field may find it difficult to classify them appropriately due to lack of experience or exposure to those plants.**
In the proposed solution, we plan on suggesting a system which would use deep learning models for image processing. This system can be trained on an ample amount of plant leaves images and tree images dataset containing pictures of various plant leaves and trees. Many prominent datasets like Flavia, Swedish Leaf datasets, etc can be used to train the model. The model will be built using a combination of 2-D Convolutional layers, Max Pooling and Dense layers. The system will take the images of the plant or tree as input and the built model will work on and predict the output. The output will be the classification of the plant.

Keywords: Convolutional Neural Network, Image Processing, Data Augmentation, Deep Learning

I. Introduction

Plants have been an integral part of human life, not only human but of the earth as well. They play an important role for the survival of the human, along with the planet as well. Plants cover about 30 percent of the land surface of earth. Around half a million species of plant have been discovered till now and the count keeps on increasing as scientists are finding more and more. Also, the task of identifying and naming the plants is a very hectic task even for researchers. A common man may not be able to identify the plants. So, we have decided to create a system where we will be classifying plants based on their leaves' images. We will take an image of a plant's leaf and then we will classify it, which type of plant it is. For training our model we are going to use the Flavia dataset which is a prominent dataset in the field of plant identification. The Flavia dataset contains highly constrained images of leaves having a white background and also there is no stem present in the images of the leaves. The Flavia dataset contains around 32 species of plant having only one training picture. After that We are planning to experiment on multiple datasets. The second one, will be a custom one, having common plant species of India, containing leaf images of Crops, Trees, Flowering plants, etc. The algorithm that we are going to use to train our model is CNN (convolution neural network). We will be first exploring performances of various prominent CNN models like Alex Net, VGG, GoogleNet-V4. These models will be applied on Dataset, and the accuracies will be monitored. Since these models were created for heavily complex tasks, the accuracy is expected to be absurd. So, we will have to fine tune these models for our application.

II. About Machine learning and Deep Learning

Machine Learning

According to Mitchell, Tom- "Machine learning (ML) can be defined as the study of techniques and algorithms that results in the improvement of the system automatically through the use of data and experience. " [1]
"It is a method related to data analysis that helps in automating the creation of various analytical models. It's a part of artificial intelligence that is based on the fact that computers can learn and evolve from data by recognizing patterns, and then making judgments with small or no human intervention." [2]
The term Machine Learning was coined by Arthur Samuel in 1959. It is a subset of Artificial Intelligence as described by various researchers. ML algorithms develop a model which is based on given sample data, commonly called the training data, which is used to make decisions or various predictions without having programmed explicitly for the same purpose. It is used in the fields where it is complex or unfeasible to create or make Algorithms that are required to perform the needed tasks. These techniques find their applications in a large variety of fields, such as in defence, computer vision, medicine, SMS filtering, Natural Language Processing, Agriculture, Forecasting etc.

Deep Learning:

It is based on Artificial Neural Learning, which is representative learning[3]. The goal or aim of Deep Learning is to mimic or replicate the functioning and structure of the human brain. Here we want to provide the machine with the capabilities of the human mind i.e thinking ability, differentiate or to have an appropriate action that is based on the decisions made by machine.

A neural network consists of multiple layers that are called nodes which resemble the neurons in the human brain. These nodes are joined to the adjacent layers.

The word ‘deep’ in ‘deep learning’ means having or using multiple layers in the network.

Convolution Neural Network

Convolution Neural Network is a part of Deep Learning. It is based on the mathematical operation “convolution” which is a way or method of combining or merging two signals that are coming from individual sources to form a third signal.

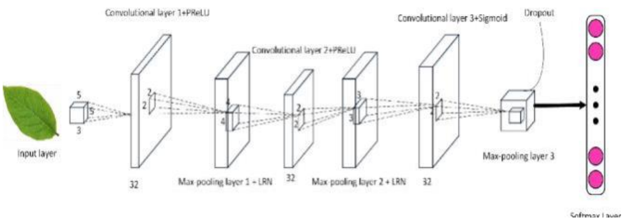

Fig 1. Convolution Neural Network[4]

This technique is generally used in Digital Image Processing . They are special cases of Neural Networks that use the concept of convolution instead of matrix multiplication. It is also used in the field of video analysis , Anomalies Detections, Speech Recognition etc. A simple CNN architecture:-

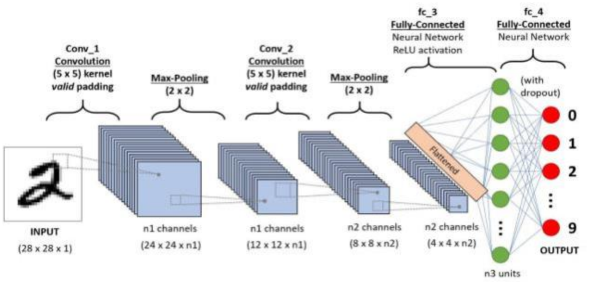

Fig 2. Basic Architecture[5].

Layers in Convolutional Neural Network-

1) Convolutional Layer :

This layer is used for the feature extraction from the input, especially image input. The process of Convolution happens in this layer. We employ a filter of size MxM, where M depends on various factors. The output obtained is known as Feature Map which contains various information regarding the input image.

2) Pooling layer :

Pooling layer reduces the size of the feature map, which is the output of the convolution layer . The goal is to reduce the computational task. There are multiple pooling methods like Max pooling, Average pooling, and Sum pooling.

3) Fully connected layer :

This layer receives an input vector which is used to produce an output vector. Where each element of the vector means the probability of an input image belonging to a certain class. Here the value associated with the input is connected to all the output values.

4) Activation function :

The activation function can be defined as the non linear changing or transformation that we usually perform on the input signal. And then the output which is now being transformed , is sent to the neuron's next layer as an input.

Different categories of activation functions are available to be used such as sigmoid, tanh, Maxout, ReLU, ELU etc.

Some prominent CNN Models are AlexNet, VGG, GoogleNet, Resnet, LeNet, DenseNet, and Inception.

III. Findings based on reviews

[6] Wang-Su and Sang-Yong used a modified version of Google Net to work on flavia dataset and achieved an accuracy of 95% on 30% leaf damage, and an accuracy of 98.6% on 60% leaf discoloration. The accuracy on fresh leaves was 99.8%

[7] Izwan Asraf and his team developed a custom neural network in 11 iterations, namely model 1 to model 11, 11 being the most accurate of them all. The team worked on classification of herbal plants with a dataset prepared from images captured at a herbal nursery. The model 11 acquired an average accuracy of 99.62% on trials with number of epochs ranging from 22 to 47. The average loss was 0.0222.

[8] Boi M Quach and his team have used custom encoders and decoders to work on the Flavia Dataset. They used information from sources like colour, vein images, and some other handcrafted features. Total 7 encoders are used, where 2 of them are 2D CNNs, one 1-D CNN for xy-projection histogram, and 4 fully connected networks for handcrafted features. Their model achieves an accuracy of 99.58% on test sets under random 10-fold cross validation. This study focuses on leaves recorded under ideal lab conditions, so real world interpretations and predictions can differ.

[9] Avesh Ali, Suraj Yadav, and other team members proposed a CNN model for Plant classification, classifying the images into 5 species of flowers. The CNN model comprised 4 Convolution layers, 4 Max Pooling Layers, and 2 Dense layers at the end to produce the output. The best accuracy achieved by their model was 96.65% on 10 epochs

[10] Xianfeng Wang and his team has developed a Multiscale CNN with attention for the recognition of plant species. It is named AMSCNN or Multiscale Convolutional Neural

Network with Attention. It uses 3 convolution layers of 3x3, 5x5, 7x7, after which, attention is employed. At the end, the Softmax function is used as the classifier in the model. 73.62% is the accuracy achieved by this model. The reason for low accuracy is imbalance in the number of different species of plants in the used dataset.

[11] Hiep Xuan Huynh and his team proposed a plant leaf recognition method by first extracting vein structure of the leaves and then feeding the data to the CNN model. The CNN model proposed constitutes 4 2-D Convolutional Layers and 2 Pooling Layers. It worked on two datasets, namely Swedish Leaf Dataset and Flavia Dataset. Unlike other models that use Shape as the parameter for classification, this model used both the shape and vein structure to classify the plants. The highest accuracy achieved by the model was 96.63%.

[12] Nurul Fatihah Sahidan and his team proposed a Plant Recognition model by the use of Solely Flower Images, or Solely Leaf Images, or a combination of both, fed to a Convolution Neural Network. The accuracies on all three experiments were 74%, 98%, and 85% respectively. They experimented by using a different number of convolution layers each time, and the best iteration had 8 Convolution Layers for Flower only dataset, 4 convolutional layers for Leaf only dataset, and 4 convolution layers for a combination of both.

Based on these reviews, the summary of the mentioned research papers along with its technology and dataset used and the results obtained is mentioned below.

Research Paper	**Model used**	**Accuracy**
[6]Plant Leaf Recognition Using CNN	Google net (by adjusting the network depth) Flavia dataset was used	98.6% on 60% discoloration 94.3% on 30% damages leaves
[7]Herbal plant recognition using DCNN	CNN model and Custom dataset of herbal plants in Malaysia	The model accuracy was found to be as 98.53%. and the test loss is 0.1140
[8]Leaf Recognition Using CNN Based Features	Pre extracted color, vein structure, and handcrafted shape, then fed to SVM for classification	99.58% accuracy
[9]Plant Species Classification with CNN	Inception V3 CNN model and custom Dataset is used	The model accuracy was found to be 96.65%. and the test loss is 0.1140
[10] Multiscale CNN with Attention uesd for Plant Species Recognition	VGG16 and public plant leaf image database named ICL	95.28% maximum accuracy
[11]Plant Identification Using New Architecture CNN Combine with Replacing the Red of Color Channel Image by Vein Morphology Leaf	CNN model And Swedish and Flavia leaf dataset	The model was 96.63% accurate on flavia dataset and 98.22% on swedish dataset
[12]Flower and leaf recognition for plant identification using CNN	Custom shallow CNN and dataset	Flower only accuracy- 74% Leaf Only Accuracy- 98% Flower and Leaf together - 85% accuracy

Although CNN and related methods have been proven to be highly accurate in recognizing plants, there are still a few problems that can be addressed to collectively improve recognition algorithms. Observing the usual problems in various models and methodologies proposed by different authors, we can induce that there are some common problems.

1. Small Dataset: CNN requires a lot of images to train on after which it can show significant improvement in recognition. The research papers showed that having a smaller dataset can decrease accuracy than what it can actually be on the same model[9], [11] and [12].

2. Ideal lab environment images: Many methods rely on images dataset obtained from ideal laboratory conditions. Thus when the model is introduced to real life conditions, it may not be as accurate as when it was when training against ideal condition images[6] and [8].
3. Data Imbalance: One of the problems in learning of CNN model is the imbalance of images in each category. It is necessary to keep the number of images roughly equal for each class.
4. Overfitting: It is a phenomenon where the model is too closely set on the training data. It can be due to a very small dataset, or the mode learning from the noise too.

IV. Proposed Methodology

The proposed methodology aims at eliminating the gaps assessed during the previous work review. Ways to remove those gaps:

1. **Data Balancing:**
   First thing to keep in mind is to have an equal number of images of each class to avoid data imbalance. This provides an equal number of samples to the model to learn from.
2. **Increasing size of Dataset:**
   Second method is to increase the dataset size. CNN models perform the best where there is plenty of data to learn from. For this, we employ a method known as data augmentation. The practice of producing variations in images from existing image collections is known as data augmentation[13]. It can be achieved by various methods like Resizing the images, Rotating them on an axis, and flipping them horizontally and vertically. Even if we consider only these operations, and consider 3 rotating operations, resizing to just one size, and horizontal and vertical flipping, then we can create 6 more images from a single image. This way, we can increase the dataset size by 6 times.

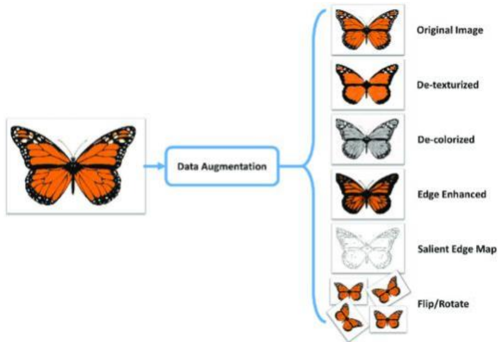

Fig 3:- Image Augmentation[14].

3. **Samples from diverse environment:**
   One problem seen in many models is that they rely on images obtained from a controlled laboratory environment. This makes it hard for the model to perform with similar accuracy in the real world. So, the dataset preparation should be done keeping this in mind. Images should comprise of leaves from various conditions, like on branches and fallen leaves.
4. **Reducing Overfitting:**
   Overfitting[15] is not very uncommon. It can happen due to learning of noise by the model due to the very high number of epochs used in training the model. This makes it hard for the model to accurately predict in a real testing environment. Overfitting can be reduced by a number of ways.

   Dropout[17] is a method where few neurons are dropped randomly. It means that this neuron is temporarily stopped from influencing next neurons in current pass

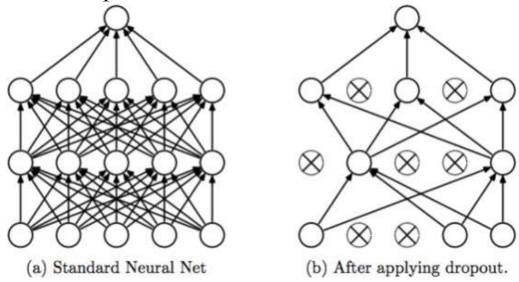

Fig 4. Dropout[16]

   Another method is **Regularization**[25]**,** and the most common ones are L1 and L2 Regularization. Regularization is based on the idea that lesser weights result in simpler models, which helps to avoid overfitting.[18]

   Early Stopping is a method where the training is stopped before reaching its target epoch numbers. The model is validated against unseen data, which is validation data, while it is fitting on training data. So, if the accuracy on this validation set is not increasing over the last few epochs, then the training is stopped at that point, because past that point, the model will only learn noise, and cause overfitting.

   Data augmentation is also used to avoid overfitting, which is already discussed above.

V. Conclusion and Future Work

Plant recognition using Deep Learning methods is a study that is currently a hot topic. Proper and accurate classification is highly necessary. By reviewing many papers and understanding them, we know that there are still a number of problems these CNN models face. Datasets like Flavia dataset and Swedish leaf dataset, and many other custom datasets are quite small in size which is not enough for proper learning of a CNN model. These problems can be overcome by techniques like Image Augmentation, Dropout, Regularization and Early Stopping.

For further work, we plan on implementing a custom CNN model while addressing the problems discussed in this paper. The dataset created will have an ample amount of images to train the model on, pre-processed to have the same sizes, an equal number of images in each class, and proper methods to prevent overfitting will be used.

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